
REMARKS

Claim 17 was amended to more distinctly point out what the Applicant regards as his invention. Support for this amendment comes from the first paragraph in the Detailed Description section, and throughout the disclosure.

The Applicant respectfully disagrees with the Office Action regarding support in the original disclosure for claims 32, 33, 34, 37, and 38. Support for claim 32 comes from originally presented claims 17, 20, 22, 24, and throughout the disclosure. Support for claim 33 comes from originally presented claims 17, 20, 22, 24, 26 and throughout the disclosure. Support for claim 34 comes from originally presented claims 17, 18, 20, 22, 24, 26 and throughout the disclosure. Support for claim 37 comes from originally presented claims 17, 20, 22, and throughout the disclosure. Support for claim 38 comes from originally presented claims 17, 20, 22, 24, 26, and throughout the disclosure.

Applicant's traverse of the restriction has its basis in the fact that the Office Action has failed to demonstrate proper grounds for restriction. M.P.E.P. § 803. Neither independence of inventions nor a serious burden on the examiner have been demonstrated. (Ibid.) A simple recitation of differences between various claims does not meet this burden. The examiner must meet the burden of demonstrating these two criteria. One way to demonstrate this is by a separate classification in the art for each of the various groups. M.P.E.P. § 806. The Applicant does not at this time take any position on specific Groups and their lack of distinctiveness or their lack of patentably distinct species. Rather, the Applicant respectfully asserts the Office must first meet the burden of demonstrating patentably distinct species.

The Examiner is invited to contact Applicant's Representative John Greaves at 801/278-9171 or the below signed attorney if there are any questions regarding this Response or if prosecution of this application may be assisted thereby.

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Title: DUAL-STACK, BALL-LIMITING METALLURGY AND METHOD OF MAKING SAME

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Respectfully submitted,

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CERTIFICATE UNDER 37 CFR 1.8: The undersigned hereby certifies that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail, in an envelope addressed to: Commissioner of Patents, Washington, D.C. 20231, on this 27 day of September, 2002.

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Docket No. 00884.523US1

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Clean Version of Pending Claims

DUAL-STACK, BALL-LIMITING METALLURGY AND METHOD OF MAKING SAME

Applicant: Madhav Datta et al.

Serial No.: 09/961,036

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17. (Amended) A process comprising:
- forming a metallization;
 - forming a refractory metal first layer over the metallization;
 - forming a refractory metal second layer over the refractory metal first layer;
 - forming a refractory metal third layer above and on the refractory metal second layer, wherein the third refractory metal is substantially the same metal as the refractory metal first layer;
 - forming a refractory metal fourth layer above and on the refractory metal third layer, wherein the refractory metal fourth layer is substantially the same metal as the refractory metal second layer; and
 - forming an electrically connective bump above the refractory metal fourth layer.
18. The process according to claim 17, wherein forming a metallization comprises:
- forming a copper metallization pad over a substrate, wherein the copper metallization pad makes contact with a metallization selected from a range of metal-one (M1) to M6.
19. The process according to claim 17, wherein forming a refractory metal first layer over the metallization comprises:
- depositing the refractory metal first layer by physical vapor deposition of a composition selected from Ni, Co, Pd, Pt, Ti, Zr, Hf, Cr, Mo, W, Sc, Y, La, and Ce.
20. The process according to claim 17, wherein forming a refractory metal first layer over the metallization comprises:
- sputtering Ti over the metallization to a thickness in a range from about 500 Å to about

2,000 Å.

21. The process according to claim 17, wherein forming a refractory metal second layer over the refractory metal first layer comprises:

depositing the refractory metal second layer by physical vapor deposition of a composition selected from Ni, Co, Pd, Pt, NiV, CoV, PdV, PtV, Ti, Zr, Hf, Cr, Mo, W, Sc, Y, La, and Ce in a solid-solution or stoichiometric ratio.

22. The process according to claim 17, wherein forming a refractory metal second layer over the refractory metal first layer comprises:

sputtering NiV over the refractory metal first layer to a thickness in a range from about 1,000 Å to about 4,000 Å.

23. The process according to claim 17, wherein forming a refractory metal third layer over the metallization comprises:

depositing the refractory metal third layer by physical vapor deposition.

24. The process according to claim 17, wherein forming a refractory metal third layer over the metallization comprises:

sputtering NiV over the refractory metal second layer to a thickness in a range from about 500 Å to about 2,000 Å.

25. The process according to claim 17, wherein forming a refractory metal fourth layer over the refractory metal first layer comprises:

depositing the refractory metal fourth layer by physical vapor deposition.

26. The process according to claim 17, wherein forming a refractory metal fourth layer over the refractory metal first layer comprises:
sputtering NiV over the refractory metal third layer to a thickness in a range from about 1,000 Å to about 4,000 Å.
27. A process comprising:
forming a metallization;
sputtering a refractory metal first layer over the metallization;
sputtering a refractory metal second layer over the refractory metal first layer, wherein the refractory metal second layer is a refractory metal alloy;
sputtering a refractory metal third layer above and on the refractory metal second layer, wherein the third refractory metal is substantially the same metal as the refractory metal first layer;
sputtering a refractory metal fourth layer above and on the refractory metal third layer, wherein the refractory metal fourth layer is substantially the same metal as the refractory metal first layer; and
plating a Sn-containing solder through a mask onto the refractory metal fourth layer to form an electrically connective bump.
28. The process according to claim 27, further comprising:
etching the first-through-fourth refractory metal layers with an etch recipe that is selective to the solder; and
reflowing the solder.
29. The process according to claim 27, further comprising
first anisotropic etching the first-through-fourth refractory metal layers with an etch recipe that is selective to the solder;

second isotropic etching the first-through-fourth refractory metal layers with an etch recipe that is selective to the solder and to the mask; and reflowing the solder.

30. The process according to claim 27, further comprising:
anisotropically etching the mask and the first-through-fourth refractory metal layers by using the bump precursor as a shadow mask; and
etching the first-through-fourth refractory metal layers with an etch recipe that is selective to the solder.
31. The process according to claim 17, wherein forming a refractory metal first layer over the metallization includes sputtering Ti over the metallization to a thickness in a range from about 500 Å to about 2,000 Å, and wherein forming a refractory metal second layer over the refractory metal first layer includes sputtering NiV over the refractory metal first layer to a thickness in a range from about 1,000 Å to about 4,000 Å.
32. The process according to claim 17, wherein forming a refractory metal first layer over the metallization includes sputtering Ti over the metallization to a thickness in a range from about 500 Å to about 2,000 Å, wherein forming a refractory metal second layer over the refractory metal first layer includes sputtering NiV over the refractory metal first layer to a thickness in a range from about 1,000 Å to about 4,000 Å, and wherein forming a refractory metal third layer over the metallization includes sputtering NiV over the refractory metal second layer to a thickness in a range from about 500 Å to about 2,000 Å.
33. The process according to claim 17, wherein forming a refractory metal first layer over the metallization includes sputtering Ti over the metallization to a thickness in a range from about 500 Å to about 2,000 Å, wherein forming a refractory metal second layer over the

refractory metal first layer includes sputtering NiV over the refractory metal first layer to a thickness in a range from about 1,000 Å to about 4,000 Å, wherein forming a refractory metal third layer over the metallization includes sputtering NiV over the refractory metal second layer to a thickness in a range from about 500 Å to about 2,000 Å, and wherein forming a refractory metal fourth layer over the refractory metal first layer includes sputtering NiV over the refractory metal third layer to a thickness in a range from about 1,000 Å to about 4,000 Å.

34. The process according to claim 17, wherein forming a metallization includes:
forming a copper metallization pad over a substrate, wherein the copper metallization pad makes contact with a metallization selected from a range of metal-one (M1) to M6; and
wherein forming a refractory metal first layer over the metallization includes sputtering Ti over the metallization to a thickness in a range from about 500 Å to about 2,000 Å, wherein forming a refractory metal second layer over the refractory metal first layer includes sputtering NiV over the refractory metal first layer to a thickness in a range from about 1,000 Å to about 4,000 Å, wherein forming a refractory metal third layer over the metallization includes sputtering NiV over the refractory metal second layer to a thickness in a range from about 500 Å to about 2,000 Å, and wherein forming a refractory metal fourth layer over the refractory metal first layer includes sputtering NiV over the refractory metal third layer to a thickness in a range from about 1,000 Å to about 4,000 Å.

35. The process according to claim 17, wherein forming a refractory metal first layer over the metallization comprises:

sputtering Ti over the metallization to a thickness in a range from about 500 arbitrary units to about 2,000 arbitrary units.

36. The process according to claim 17, wherein forming a refractory metal first layer over the metallization includes sputtering Ti over the metallization to a thickness in a range from about

500 arbitrary units to about 2,000 arbitrary units, and wherein forming a refractory metal second layer over the refractory metal first layer includes sputtering NiV over the refractory metal first layer to a thickness in a range from about 1,000 of the arbitrary units to about 4,000 of the arbitrary units.

37. The process according to claim 17, wherein forming a refractory metal first layer over the metallization includes sputtering Ti over the metallization to a thickness in a range from about 500 arbitrary units to about 2,000 arbitrary units, wherein forming a refractory metal second layer over the refractory metal first layer includes sputtering NiV over the refractory metal first layer to a thickness in a range from about 1,000 of the arbitrary units to about 4,000 of the arbitrary units, and wherein forming a refractory metal third layer over the metallization includes sputtering NiV over the refractory metal second layer to a thickness in a range from about 500 of the arbitrary units to about 2,000 of the arbitrary units.

38. The process according to claim 17, wherein forming a refractory metal first layer over the metallization includes sputtering Ti over the metallization to a thickness in a range from about 500 arbitrary units to about 2,000 arbitrary units, wherein forming a refractory metal second layer over the refractory metal first layer includes sputtering NiV over the refractory metal first layer to a thickness in a range from about 1,000 of the arbitrary units to about 4,000 of the arbitrary units, wherein forming a refractory metal third layer over the metallization includes sputtering NiV over the refractory metal second layer to a thickness in a range from about 500 of the arbitrary units to about 2,000 of the arbitrary units, and wherein forming a refractory metal fourth layer over the refractory metal first layer includes sputtering NiV over the refractory metal third layer to a thickness in a range from about 1,000 of the arbitrary units to about 4,000 of the arbitrary units.

39. The process according to claim 17, further including:
nitriding at least one of the metal second layer and the metal fourth layer to form a nitrided metal alloy or a nitrided vanadium-doped metal.
40. The process according to claim 17, wherein the refractory metal first layer, the refractory metal second layer, the refractory metal third layer, and the refractory metal fourth layer include a four-metal-layer stack, the process further including:
plating a bump precursor over the four-metal-layer stack.
41. The process according to claim 17, wherein the refractory metal first layer, the refractory metal second layer, the refractory metal third layer, and the refractory metal fourth layer include a four-metal-layer stack, the process further including:
electroless plating a bump precursor over the four-metal-layer stack.
42. The process according to claim 17, wherein the refractory metal first layer, the refractory metal second layer, the refractory metal third layer, and the refractory metal fourth layer include a four-metal-layer stack, the process further including:
plating a bump precursor over the four-metal-layer stack; and
further processing the four-metal-layer stack to remove the four-metal-layer stack except under the bump precursor.
43. A process comprising:
forming a metallization;
forming a Ti first layer over the metallization to a thickness in a range from about 500 arbitrary units to about 2,000 arbitrary units;
forming a NiV second layer over the Ti first layer to a thickness in a range from about 1,000 of the arbitrary units to about 4,000 of the arbitrary units;

forming a Ti third layer over the NiV second layer to a thickness in a range from about 500 arbitrary units to about 2,000 arbitrary units; and

forming a NiV fourth layer over the Ti third layer to a thickness in a range from about 500 arbitrary units to about 2,000 arbitrary units.

44. The process according to claim 43, wherein the Ti first layer, the NiV second layer, the Ti third layer, and the NiV fourth layer include a four-metal-layer stack, the process further including:

plating a bump precursor over the four-metal-layer stack; and

further processing the four-metal-layer stack to remove the four-metal-layer stack except under the bump precursor.

45. The process according to claim 43, further including:

plating a Sn-containing solder through a mask onto the NiV fourth layer to form an electrically connective bump;

etching the first-through-fourth layers with an etch recipe that is selective to the solder; and

reflowing the solder.